VINYL CHLORIDE

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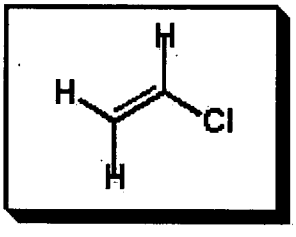
CHEMISTRY AND RELATED PROPERTIES

Vinyl Chloride (at room temperature) is a flammable, colorless gas with a sweet odor. It is used in the plastics industry, often to produce PVC (polyvinyl chloride). It is also used as a refrigerant, and in organic synthesis reactions. It may be prepared by halogenation with ethylene dichloride and alcoholic potassium.

Chemical Formula: C_2H_3Cl

Alternate Name: chloroethene, chloroethylene, ethylene monochloride

Structure:



Molecular Weight: 62.50 g/mol

Melting / Boiling Point: -153.8° C / -13.37° C

Density: (21.1° C and 1 atm) → 2.56 kg/m^3 (Gas)

→ 908.41 kg/m^3 (Liquid)

Solubility (in Water): Slight (8800 mg/L) @ 25° C
(High Solubility in Alcohol, Ether, carbon tetrachloride, benzene)

Henry's Law Contant: 0.0278 atm.m3/mde@ 24° C

Octanol:Water: $\log_{Kow}$ 1.62 [K_{ow} 41.7 (Calculated)]

Soil Partition Coefficient (K_{oc}): 56 (estimated)

Vapour Pressure: 2530 mm Hg @ 20° C

Flash Point: -78° C (-112° F)

Emmission Limit: 10ppm or 2kg/day (Process Vent)

DETECTION IN AIR

Gas Chromatography may be used for a range of 0.008 to 5.2 mg/m3 using flame ionization detection. For qualitative detection, we may use a Drager detector tube for vinyl chloride. A change in color from from violet to pale brown indicates the presence of vinyl chloride.

DETECTION IN WATER

For a range of 40 to 400 ppm, presence may be determined by partition infrared spectrophotometry. Qualitative detection may be facilitated by infrared spectroscopy. (Environment Canada, 1992)

MANUFACTURE, QUANTITY AND DISTRIBUTION

Vinyl chloride is most commonly made by the "balanced process" in which ethylene is reacted to produce ethylene dichloride, which in turn is dehydrochlorinated to produce vinyl chloride. The raw materials used in the manufacture of vinyl chloride are ethylene and hydrogen chloride.

Ethylene is reacted with hydrogen chloride and oxygen to produce ethylene dichloride. The reaction is usually carried out in the vapour phase over catalysts containing copper chloride as the active catalyst. The overall reaction is as follows:

$$CH_2=CH_2 + 2HCl + \tfrac{1}{2} O_2 \rightarrow ClCH_2CH_2Cl + H_20$$

The ethylene dichloride is purified to remove any $FeCl_3$ (which poisons catalysts in the next phase) and is reacted at 2500-3000 kPa at temperatures of 425-550°C to yield vinyl chloride and hydrogen chloride. The hydrogen chloride is recycled to the first step (thus the name "balanced process" for this entire procedure).

$$ClCH_2CH_2Cl \rightarrow CH_2=CHCl + HCl$$

The resulting vinyl chloride is purified by distillation to remove the byproducts (unreacted material, chlorinated hydrocarbons, hydrocarbons). This vinyl chloride monomer (VCM) is combined with an agent called an initiator which start the reaction that produces a fine-grained, white powder known as polyvinyl chloride (PVC) resin, or simply "vinyl".

Quantities Produced and Geographic Distribution

- Vinyl chloride monomer is used primarily (99%) for the production of polyvinyl chloride.
- In 1996, almost 22 million metric tons of VCM were required for PVC production worldwide.
- The world market for VCM in 1996, based on an average U.S. price of 20 cents per pound, was approximately $10 billion (U.S.).
- Despite the continued globalization of the industry, VCM production and consumption remain concentrated in North America, Western Europe and Japan. Taken together, these regions accounted for 67% of world capacity and 63% of consumption in 1996. It is expected that the percentage of VCM production in Asian countries, excluding Japan, will increase.
- Polyvinyl chloride demand in the US is forecast to grow 3.4 percent per year to 14.4 billion pounds in 2002. valued at $6.2 billion
- In North America, the leading VCM producers are Dow Chemical and Geon. In Western Europe, they are EVC International and Solvay. In Japan, the largest producers are Tosoh and Kaneka.

Canadian producers of vinyl chloride and PVC:

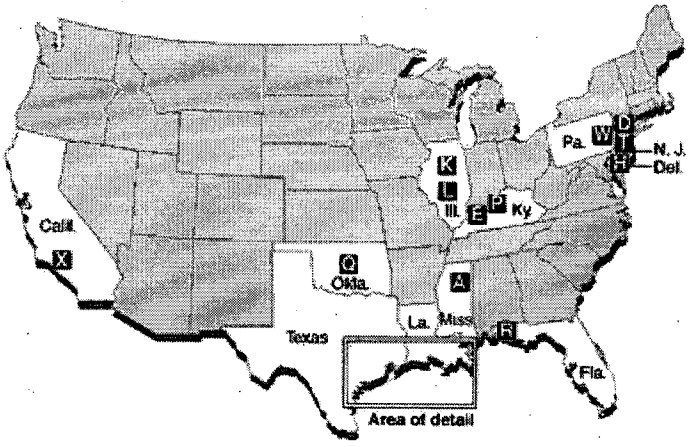
Company	***Location***	***Product***
Dow Chemical Canada Inc.	Sarnia, Ontario	Vinyl chloride
Dow Chemical Canada Inc.	Fort Saskatchewan, Alberta	Vinyl chloride

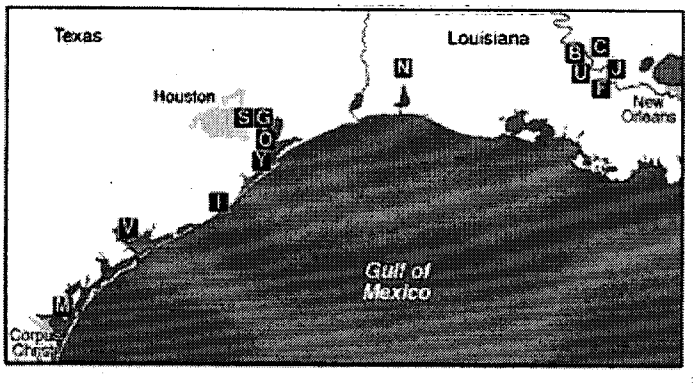
B.F. Goodrich Canada Inc.	Niagara Falls, Ontario	Polyvinyl chloride
B.F. Goodrich Canada Inc.	Fort Saskatchewan, Alberta	Polyvinyl chloride
Esso Chemicals Canada	Sarnia, Ontario	Polyvinyl chloride

Vinyl capitals

Texas and Louisiana are the heart of manufacturing in the vinyl industry. Here are the locations of vinyl chloride, ethylene dichloride and PVC plants in this region and elsewhere:

	Location	Companies
A	Aberdeen, Miss.	Condea Vista
B	Addis, La.	Borden
C	Baton Rouge, La.	Formosa
D	Burlington, N.J.	Colorite Polymers
E	Calvert City, Ky.	Westlake
F	Convent, La.	OxyChem
G	Deer Park	Geon, OxyChem
H	Delaware City, Del.	Formosa, Kaneka Corp.
I	Freeport	Dow, Shintech
J	Geismar, La.	Borden, Vulcan
K	Henry, Ill.	Geon
L	Illiopolis, Ill.	Borden
M	Ingleside	OxyMar
N	Lake Charles, La	Certain Teed, Condea Vista, PHH Monomers, PPG Industries
O	LaPorte	Geon
P	Louisville, Ky	Geon
Q	Oklahoma City	Condea Vista
R	Pace, Fla.	Westlake
S	Pasadena	OxyChem
T	Pedricktown, N.J.	Geon
U	Plaquemine, La.	Dow, Georgia Gulf
V	Point Comfort	Formosa
W	Pottstown, Pa.	OxyChem
X	Santa Clarita, Calif.	Keysor-Century
Y	Texas City	Union Carbide





Fate of Vinyl Chloride After Use

Most of the vinyl chloride that enters the environment comes from the plastics industries, which release it into the air or into waste water. Vinyl chloride has entered the environment at hazardous waste sites as a result of its improper disposal or leakage from storage or transport containers or from spills.

Vinyl chloride is shipped as a liquefied compressed gas. It has a boiling point of –13.4°C at a pressure of 1 atmosphere. Consequently, when it is spilled onto soil extensive evaporation will occur. While most will be lost to evaporation, the balance will infiltrate the soil. Evaporation will continue within the soil but at a reduced rate.

When spilled on water, some of the material will dissolve, and the rest will evaporate to the atmosphere. Vinyl chloride spills on soil surfaces will partly vaporize, and partly adsorb onto the soil at a rate dependent on the soil type and its degree of saturation with water. Downward transport of the liquid toward the groundwater table may cause environmental concerns.

General Source Assessment

Vinyl chloride is not normally found in urban, suburban, or rural air in amounts that are detectable by the usual methods of analysis. However, vinyl chloride has been found in the air near plastics industries, hazardous waste sites, and landfills. The amount of vinyl chloride in the air near these places ranges from trace amounts to 0.041 ppm of air, but may exceed 1 ppm.

Vinyl chloride can also be found in drinking water from contaminated wells, but how often this occurs is not known. Most drinking water supplies do not contain vinyl chloride. In a 1982 survey, vinyl chloride was found in less than 1 percent of the 945 groundwater supplies tested in the United States. The concentrations found in groundwater were up to 0.008 ppm, with a detection limit of 0.001 ppm. Other studies have reported groundwater vinyl chloride concentrations at or below 0.38 ppm.

Vinyl chloride has been found in at least 133 of 1177 hazardous waste sites on the National Priorities List (NPL) in the U.S. It is unlikely that vinyl chloride will build up in plants or animals that one might eat.

BIODEGRADATION

When in water, vinyl chloride does not appear to be sorbed, degraded or affected at all by microorganisms (experimentation included both bacterial and fungal populations). Chemical degradation is also insignificant in water. Vinyl chloride evaporates rapidly, and its half life in water at a depth of 1m is estimated to be 26 minutes. In air, vinyl chloride will be photodegraded to hydrogen chloride or formyl chloride, which in turn reacts to produce carbon monoxide and hydrogen chloride. The half life in air is estimated to be approximately 2 days.

SPILL CONTROL

- Restrict access to site
- Issue 'flammable' warning
- Call fire dept. and notify manufacturer
- Eliminate all sources of ignition
- Stop and contain flow
- Avoid contact and inhalation - stay upwind
- Keep contaminated water from entering sewers
- If on fire: Foam, dry chemicals, CO_2, H_2O, or fog can be used

SOIL SPILL

Construct barriers and pump out liquid; if this is unsafe, let evaporate

WATER SPILL

Limit spreading by using natural barriers or booms. Activated carbon can be applied at 10 percent the spill amount over the region occupied by 10mg/L or greater concentrations - mechanical dredges can then be used to remove the carbon, aeration of contaminated water will also substantially remove the contaminant

PROTECTION REQUIRED WHEN DEALING WITH A SPILL

- Impervious clothing and a self contained breathing apparatus
- Butyl rubber, polyurethane, styrene-butadiene rubber and Viton all demonstrate breakthrough times of approximately one hour
- Any clothing which becomes contaminated should be removed immediately and washed thoroughly
- Eye wash stations and chemical safety showers should be readily available for anyone exposed as well as for the clean up crew
- It is toxic by inhalation and skin contact.

ENVIRONMENTAL PATHWAYS

- Liquid vinyl chloride evaporates easily into the air. Vinyl chloride, if it is near the surface of soil or water, can also evaporate.
- Vinyl chloride in the air can break down within a few days to other substances, some of which can be harmful.
- Small amounts of vinyl chloride can dissolve in water.
- Vinyl chloride formed from the breakdown of other chemicals can enter groundwater.
- Vinyl chloride is unlikely to build up in plants or animals.
- When spilled in water, it can become bioconcentrated in the aquatic species such as fish

HEALTH EFFECTS

ACUTE (SHORT TERM) EXPOSURE

- CNS effects such as dizziness, headaches and giddiness
- Weakness
- Abdominal pain
- Gastrointestinal bleeding
- HepatomegalyPallor or cyanosis at extremities

CHRONIC (LONG TERM) EXPOSURE

- 'Vinyl Chloride Disease' - liver damage, effects on the lung, poor circulation in the fingers, changes in the bones at the end of the fingers, thickening of the skin and changes in the blood

- Carcinogenic, Mutagenic, Teratogenic

References

1. Budavari, S. et al. *The Merck Index (12th ed.)*. Merck Research Laboratories, Whitehouse Station NJ, 1996. pp. 1705-6.
2. Environment Canada. *Vinyl Chloride Industry Environmental Status Report (1987-90)*. Environment Canada, Ottawa, 1992. pp. 2, 73-75.
3. http://www.atsdr.cdc.gov/ToxProfiles/phs8825.html (October 14, 2000)
4. http://physchem.ox.ac.uk/MSDS/V/vinyl_chloride.html (September 22, 2000)
5. http://ceh.sric.sri.com/Public/Reports/696.6000/ (October 14, 2000)
6. http://www.usadata.com/cgi-bin/usasearch.cgi (October 14, 2000)
7. http://www.vinylinfo.org/materialvinyl/process.html (October 14, 2000)
8. http://esc.syrres.com/interkow/webprop.exe?CAS=75-01-4 (October 14, 2000)